EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Health Effects of Coal-Fired Power Plant Emissions

Annette C. Rohr, Sc.D.

EUEC 2006

Tucson, AZ

January 23, 2006

Overview

- Background
- What We Know…….
- What We Don't Know……
- EPRI Toxicology Field Studies:
  - TERESA: Toxicological Evaluation of Realistic Emissions of Source Aerosols
  - Tri City Concentrated Ambient Particle Study
- Conclusions

Background

- NAAQS for $PM_{2.5}$ is driven by health effects
- $PM_{2.5}$ from power plants:
  - Primary particles: emitted directly from plants; very low due to widespread use of particulate matter controls (e.g., ESPs, baghouses) in the U.S.
  - Secondary particles: formed through oxidation of SO_2 to sulfate downwind of plants.
- Most of the concern over potential health effects focuses on secondary PM, since this material comprises a significant proportion of PM mass in many regions of the U.S.

Key Issues

- How important are power plant emissions in $PM_{2.5}$-related health effects?
- What is the relative importance of different PM sources and components?

What We Know……

- Toxicology:
  - Single component studies: little effect of sulfate or acid aerosol in animals or human volunteers except at very high concentrations
  - Source-focused studies: use of lab-scale combustors or collected coal fly ash
- Epidemiology:
  - Associations between sulfate and health effects observed

What We Don't Know……

- No assessment of the toxicity of actual plant emissions
- No information on the toxicity of actual secondary particles formed through SO_2 conversion in the atmosphere

TERESA: Overview

Approach:

- Evaluate toxicity of *secondary* particles from power plants, at power plants
- Expose rats to multiple simulated atmospheric conditions
- Examine mobile source emissions using same methods

Project Team:

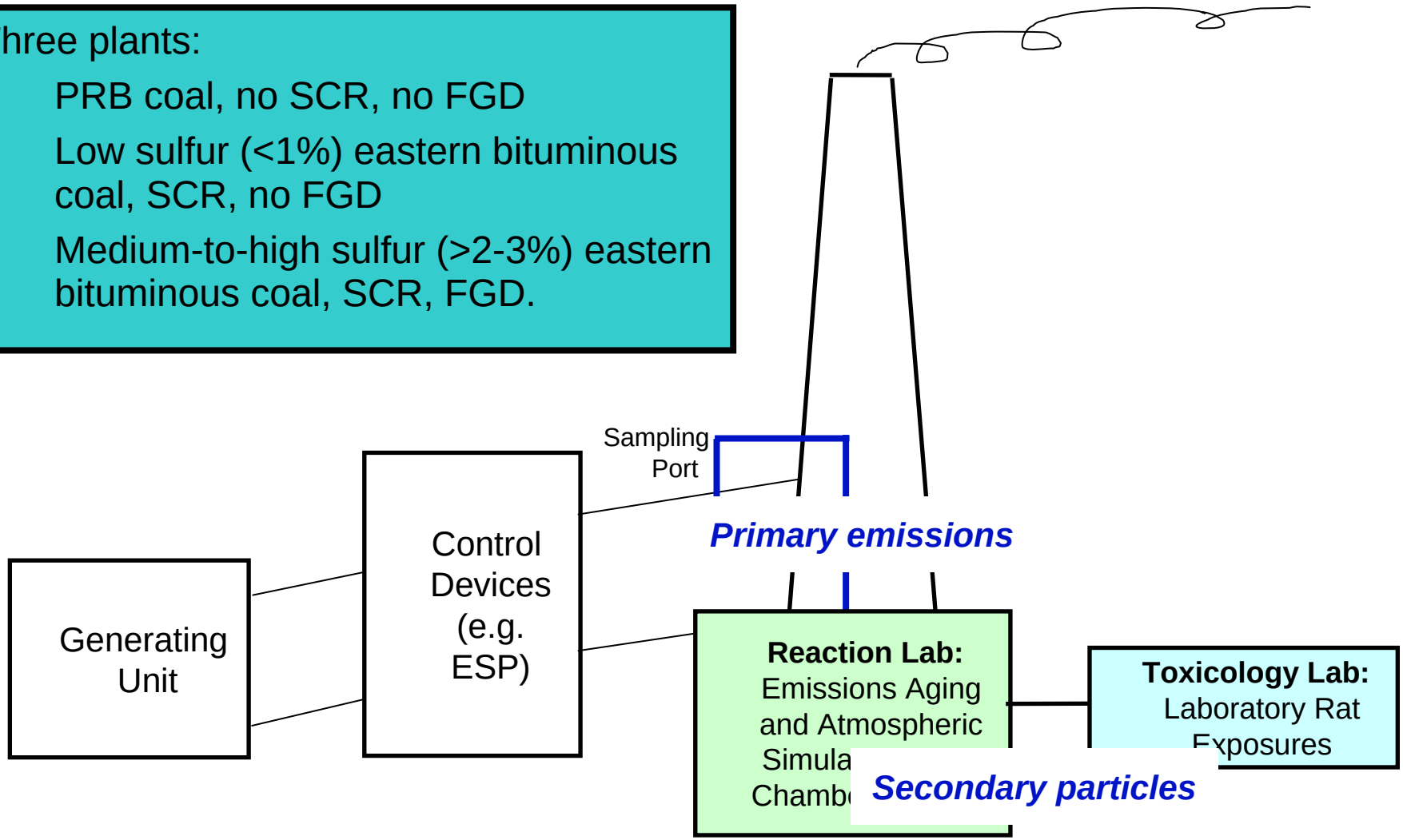
- EPRI, Harvard School of Public Health

Supported in part by DOE-NETL
(Cooperative Agreement DE-FC26-03NT41902)

TERESA: Toxicological Evaluation of Realistic Emissions of Source Aerosols

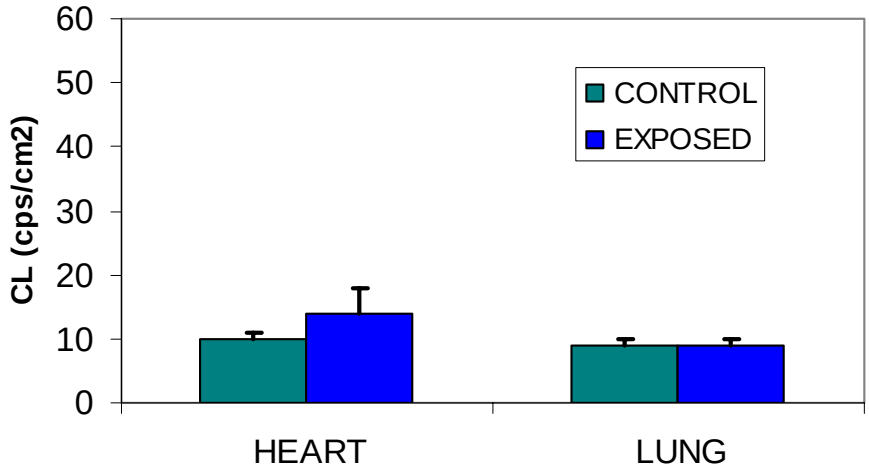
Three plants:

- PRB coal, no SCR, no FGD
- Low sulfur (<1%) eastern bituminous coal, SCR, no FGD
- Medium-to-high sulfur (>2-3%) eastern bituminous coal, SCR, FGD.

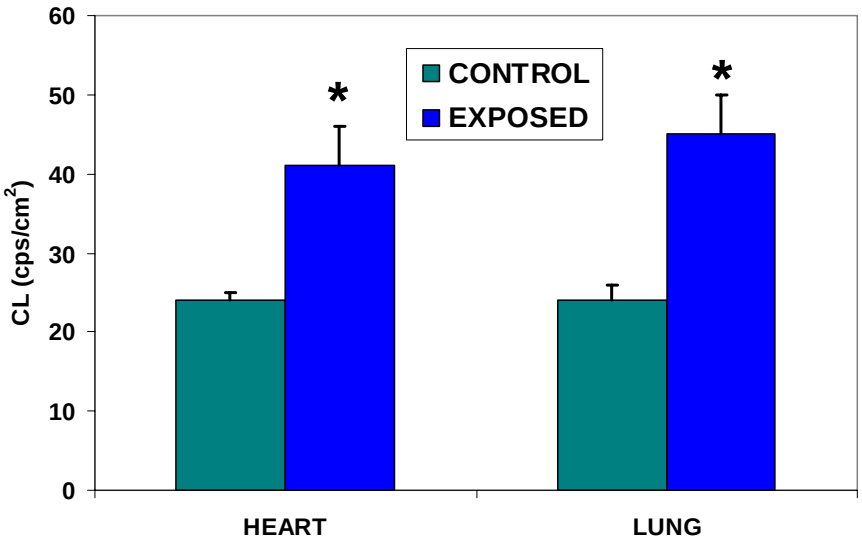


Plant 1: Oxidative Stress in Heart and Lung Tissue

Oxidized Emissions (Secondary Particles) + Secondary Organic Aerosol (SOA)
(*n*=8 in each group)



Boston Particles
(Gurgueira *et al*., 2002)
(*n*=4-6 in each group)



Plant 2

- Pulmonary effects:
  - Minor/inconsistent breathing pattern changes with some scenarios
  - Increased lung oxidative stress in one scenario (oxidized emissions + SOA)
- Cardiac effects:
  - No significant change in heart rate or heart rate variability
  - Higher rate of premature ventricular beats (arrhythmias) after 4 hours of exposure compared with control animals (oxidized, neutralized + SOA)
- Summary:
  - Effects appear to occur in scenarios with SOA
  - Additional analyses underway to determine which components are most correlated with effects

TERESA: Conclusions and Future Directions

- TERESA results to date suggest few/inconsistent effects of power plant emissions on laboratory rats
- But…we don't have all the data yet
- Need to understand how exposures at Plants 1 and 2 differ
- Plant 3 fieldwork next summer
- Mobile source component to begin in 2007 (funded through the Harvard/EPA PM Center)

Tri City Concentrated Ambient Particle Study (Tri City CAPS)

Cardiopulmonary Toxicity Induced by Ambient Particulate Matter: Inhalation Toxicology Studies Using a Mobile Particle Concentrator in Regions Dominated by Power Plant and Mobile Source Emissions

Approach:

- Station ambient particle concentrator/mobile lab at 3 locations for 2 seasons
- Expose rats to CAPs for 8 hrs/day for 13 days
- Link responses to PM sources and components

Project Team:

- EPRI, Michigan State University, University of Michigan

Supported in part by DOE-NETL (Cooperative Agreement DE-FC26-03NT41902)

Location of Study Sites

Downtown Detroit, MI

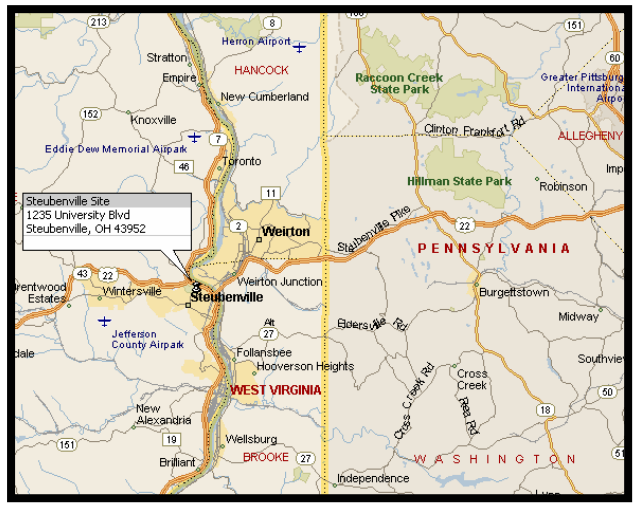
Dominated by diesel and gasoline emission-derived PM

Steubenville, OH

Dominated by power plant and local industrial emissions

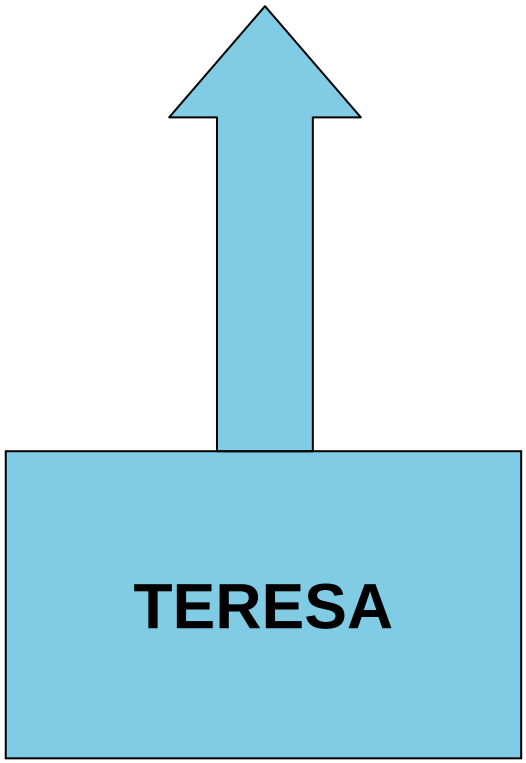
Maurice K. Goddard State Park, NW PA

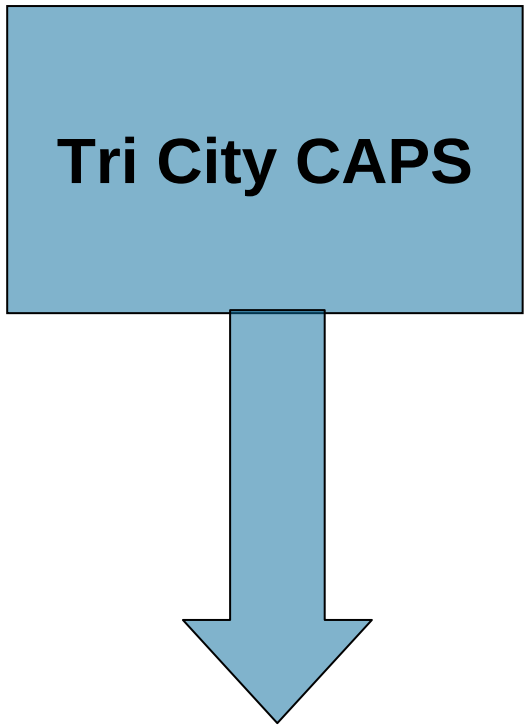
Rural site; dominated by power plant emissions



Complementary Approach to TERESA

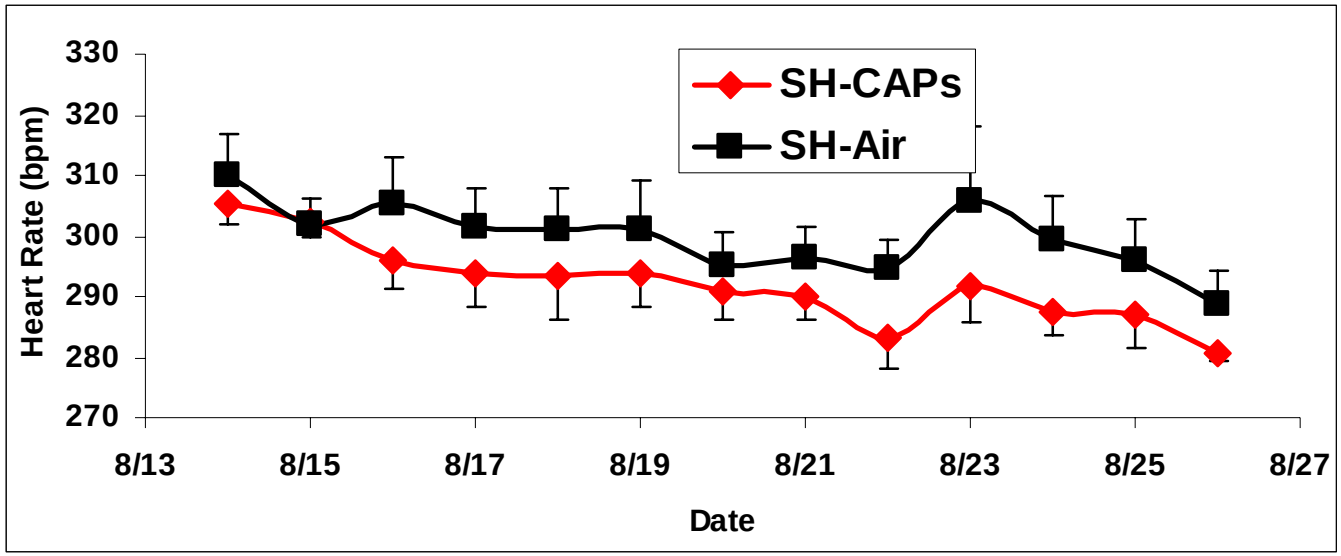
Bottom-up approach (start with controlled sources)

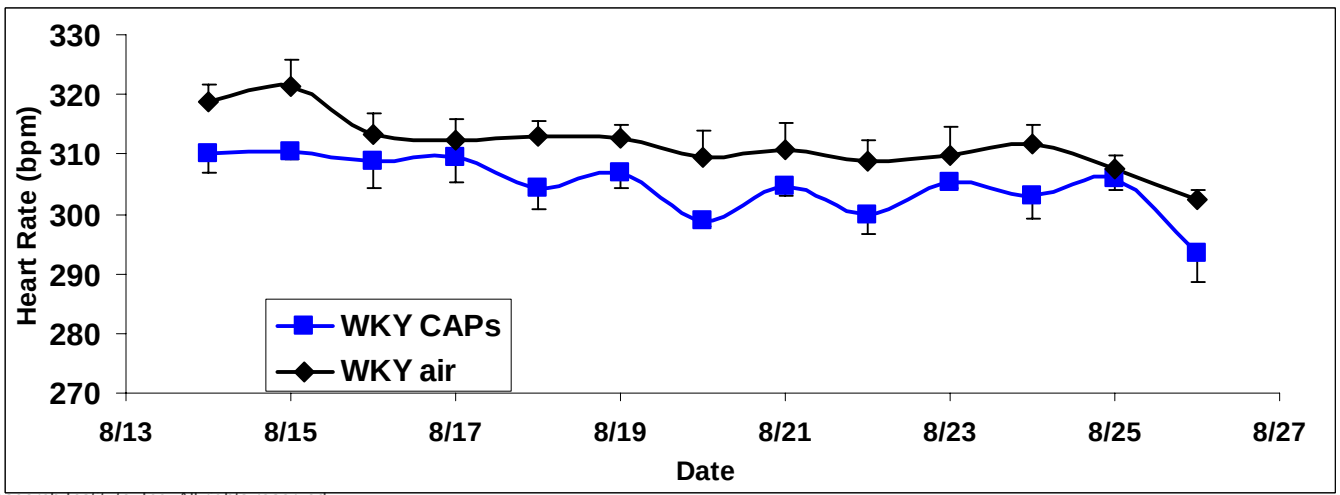




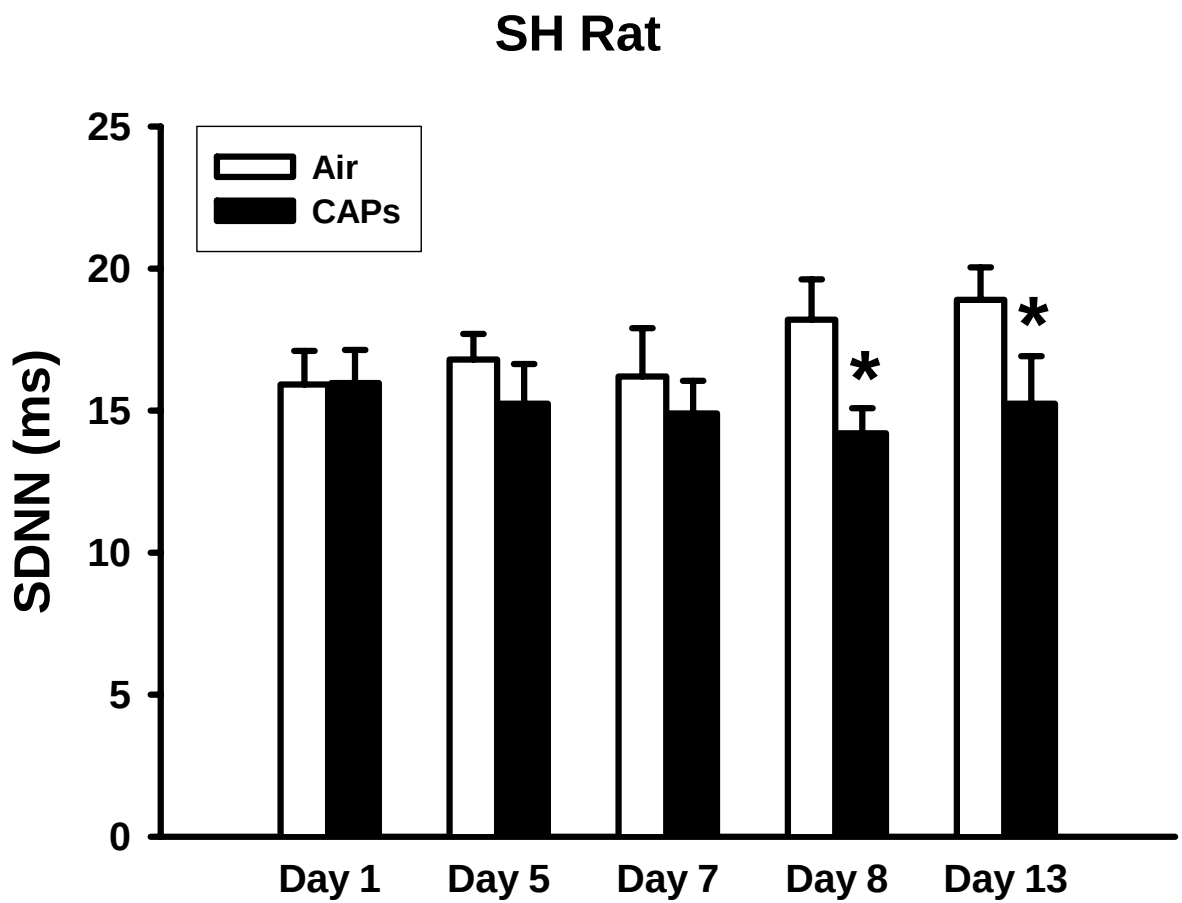
Top-down approach (start with ambient PM, tease out effects of specific sources)

Detroit CAPs Cause Decreased Heart Rate Pilot Study, Summer 2004





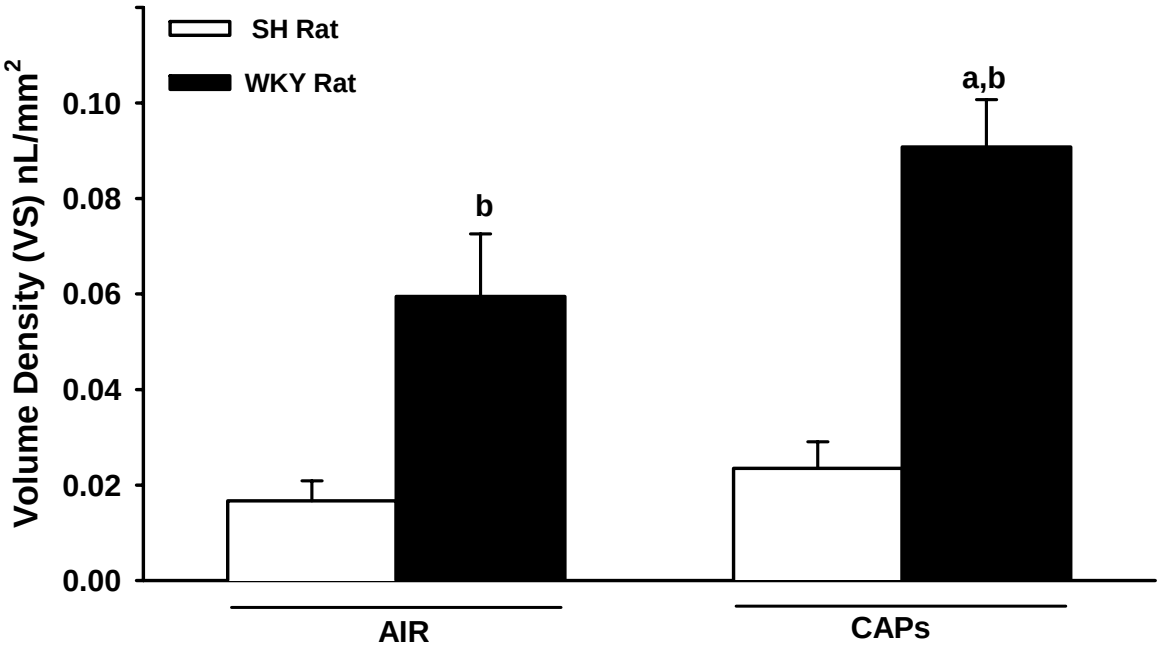
Heart Rate Variability Changes
Detroit, Summer 2004



Pulmonary Effects
Detroit, Summer 2005

Intraepithelial Mucosubstances in Proximal Pulmonary Airways

Wistar-Kyoto (WKY) and Spontaneously Hypertensive (SH) Rats
Exposed to Concentrated Air Particles (CAPS) for 2 Weeks
Detroit, MI, July 2005



a = Significantly different from WKY receiving Air, ($p \leq 0.05$).

b = Significantly different from respective SHR group, ($p \leq 0.05$).

Tri City CAPS: Conclusions and Future Directions

- Completed Detroit-Summer fieldwork, beginning winter season in 2 weeks
- Mobile source-dominated particles appear to have both cardiac and pulmonary effects
- Analyses underway to explore associations of PM components and sources with biological responses
- First Steubenville sampling round this summer

Conclusions

- Innovative approaches are needed to determine the relative importance of different PM sources and components in adverse health effects
- TERESA: showing some biological effects with power plant emissions
- Tri City CAPS: showing mobile source-dominated PM causes alterations in cardiac function